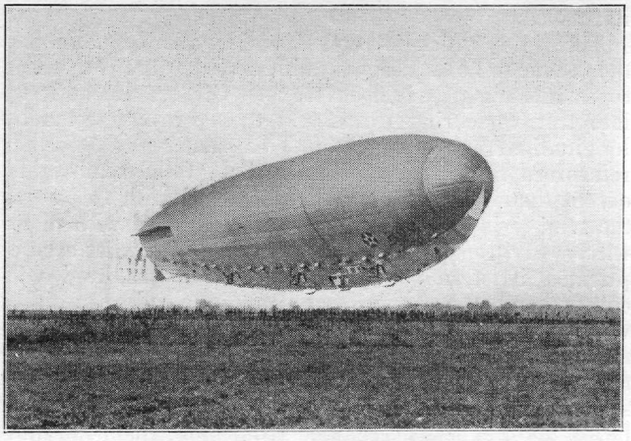
COMMERCIAL AIRCRAFT

A Discussion of the Commercial Uses of Aircraft

By L. D. LUTZENBURGER, '24

WE all know that facility of locomotion is the index of civilization. Hence the great importance of our relatively new and fast means of transportation, namely, aircraft. It is surprising how little is known of the possibilities of aircraft by people in general, and especially the "wide awake" business man. The average individual's knowledge of aircraft can be summed up in the idea that aircraft is very unsafe and only used by the foolhardy. This is due to the sensational newspaper publicity given every little accident. No accounts are given regarding the thousands of miles traveled every day along the various air routes on a night and day schedule maintained at an accuracy unapproachable by the railroads. It is unnecessary to consider, or even include, foreign air traffic to fulfill this statement, for our own air mail will—and is. They do this every twenty-four hours, 365 days a year. Incidentally they are doing this mostly with old wartime equipment, the crudity of which if contrasted to present design, would compare about as favorably as Darius Greene's flying machine in contrast to the traveling rug of Arabian Nights fame.



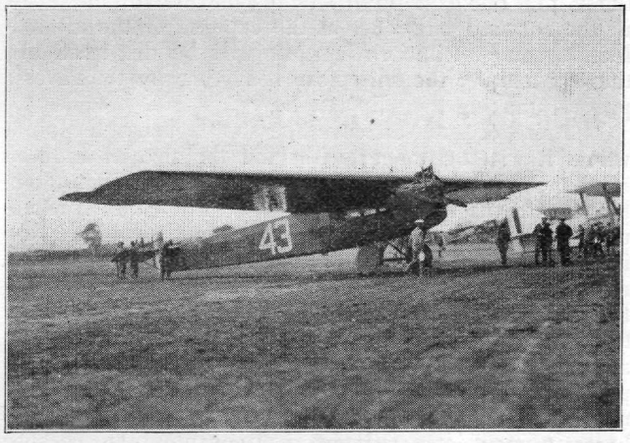
THE ROMA
A Semi Rigid Type Aircraft

Regarding the safety of aircraft let us compare the ratio of automobile accidents to the total number of autos and we find the ratio exceeding, in one year, the ratio of aircraft accidents to the number of aircraft during the entire period of aviation. To use a specific example let us consider the use of hydrogen-filled Zeppelins in Germany before the war. Even then in their comparative state of crudity, they carried more than 100,000 passengers covering a total of 4,000,000 miles without injury to a single person. Of course there is always the dyspeptic pessimist and others who refuse to acknowledge the possibilities of any new means of advancement. They are the type who twenty-five years ago, upon seeing the first automobile chugging down the road, said, "Yeah, but 'tain't practical." Now the same complacent individual leans back in his "unpractical" automobile, after reading about such achievements as the "Round the World Flight" or the 5,000-mile non-stop flight of the Los Angeles from Friedrichshafen, Germany, to Lakehurst, N. J., and then says, "Yes, but it isn't practical."

Due to the varied use of aircraft, specialization has entered the same as in other fields. As the commercial and military uses of aircraft differ so widely, two general classes have sprung up, commercial and military. There is as much difference between these two classes as between the first line superdreadnought and the passenger liner or tramp steamer.

First let us scan briefly the charactertistics, inherent or otherwise, of the various kinds of aircraft, so as to be able to contrast the suitabilities of different types with regard to their commercial possibilities. We may divide aircraft into two main divisions, lighter-than-air craft and heavier-than-air craft.

The lighter-than-air craft use a volume of some gas, lighter than air, to give the necessary lift, that is, they displace a greater weight of air than their own weight. Thus their useful load is approximately equal to the difference between the weight of displaced air and their own weight. Approximately equal because such craft, if provided with motive power, can nose up into the air, thereby using this power for additional lift. This additional lift, when it is used, enables a ship to reach greater altitude than that alone obtainable by the static lift of its gas. At the end of a trip, instead of valving gas to make up for the loss in weight of fuel consumed, this power is used to drive the ship to theg round, thereby saving a considerable amount of gas.



A FOKKER MONOPLANE
A Passenger Plane Now in Use in Europe

The heavier-than-air craft are, of course, heavier than the air they displace. Hence, they must secure lift by some mechanical means. For example, by the reaction of the air upon a moving surface; the lift obtained by rotating wings or propellers; the flapping of surfaces corresponding to the flapping of a bird's wings; by soaring, which is yet to be definitely solved, and is the means used by such birds as the buzzard and sea-gull; by cylinders rotating in an air current; or by other methods or applications as yet unknown.

Now let us review the four classes of lighter-than-air craft. They are the free balloon, non-rigid, semi-rigid, and rigid. The free balloon is of no commercial use

in itself. It is used to train lighter-than-air craft personel in navigation, meteorology, free ballooning, and for racing, which is an international sport.

The non-rigid is the second step in lighter-than-air craft progress. The non-rigid is the type craft erroneously referred t oas a "blimp." In reality a "blimp" is one of the expedients evolved by the British for submarine patrol during the war. It is a hybrid affair and was constructed by suspending an obsolete airplane fuselage from a non-rigid gas bag. The non-rigid is merely the addition of motive power, an engine, to a balloon whose gas bag has been elongated into a cigar shape in order that it may pass through the air with more ease. Control surfaces have been added which are mounted on the rear of the gas bag and consist of horizontal and vertical stabilizers, to which are hinged horizontal and vertical rudders for altitude and directional control.

The largest non-rigid type in this country is the D C type. This ship has a capacity of 200,000 cubic feet and is about 200 feet long and 60 feet in height. It has a high speed of 60 miles per hour and an endurance of ten hours at this speed. The total lift is 12,000 pounds with a useful load of 4,000 pounds. In this type of craft the shape of the gas bag is maintained by internal gas pressure which amounts to a few ounces per square foot, gage. The expansion and contraction of the gas is taken care of by two balloonets, or air bags, inside the main envelope. Thus any deficiency in the volume of gas is taken care of by the air contained in these balloonets, which is automatically supplied and at the necessary pressure by an ai rscoop mounted on the outside of the envelope so as to catch the air from the propeller. The use of two balloonets, in all but the smallest types, is to enable the crew to trim, or balance the ship. For example, by increasing the volume of air in the forward balloonet at the expense of the aft balloonet, some of the lifting gas will be displaced aft, thereby making the ship nose heavy, or by the reverse process ,making the ship tail heavy.

The size of such an envelope soon reaches the point where it will no longer withstand the stresses induced by maneuvering and cross winds. This condition, combined with the increasingly difficult problem of distributing the larger loads along the envelope so as to avoid its buckling, makes the inherent size of such aircraft relatively small in contrast to semi-rigid and rigid types. It can readily be seen that increasing the ratio of length to diameter in order to obtain a better streamline form and hence increase the maximu mspeed or reduce the power required for a given speed, increases the above mentioned problems. As a result, the non-rigid is inherently inefficient: first in fuel consumption, because of its ineffective form of envelope; second in speed, as the flexible structure makes it impracticable to force it through the air at high speed.

The semi-rigid is an intermediate stage between the non-rigid and the rigid. It has one gas bag the same as the non-rigid, but the problem of distributing the loads and keeping the bag from buckling has been solved by the addition of a keel, a long metal truss of triangular cross section, fastened along the bottom of the bag from nose to tail. All the motors and other loads are carried directly by this keel, so that the loads and stresses are distributed along the entire length of the envelope. The control surfaces are mounted in the rear of the keel, which permits a more rigid mounting and relieves the envelope of the direct stresses from these surfaces. The envelope is further reinforced by a nose cap, constructed integral with the keel. This nose cap absorbs or transmits the stresses incident to the envelope's passage through the air. This form of lighter-than-air craft has the advantage over the rigid type that it is of simpler construction, lower first cost, and has a greater proportion of available load in relation to its own weight.

However, the simpler envelope construction, that is, the use of but one gas bag, is more than offset by the more efficient envelope form and safer envelope and the gas cell construction of the rigid types. The night frolic of the Shenandoah when it was torn from its mooring mast by a gale, illustrates the greater value of multibag construction. The nose, or mooring cap, was completely torn from the envelope, having been correctly designed to be the first member to fail, and though the two forward gas cells were ripped open, the ship was safely weathering the storm five minutes after it had broken away. Under the same conditions, a semi-rigid with only one gas bag would have crashed to the ground. The high resistance offered by the semi-rigid in its passage through the air, from its external keel and its rough form of envelope, makes it a slow speed craft. If it were forced up to the speed of a rigid the fuel consumption would be prohibitive. This type of craft is the design of Signor Nobile and was introduced in this country by the advent of the Roma, which the United States bought from Italy. Unfortunately it was destroyed by a failure in the elevator mechanism, and the consequent explosion of its hydrogen and gasoline when it crashed.

The rigid, which is represented by the Zeppelin and the Schuette-Lonz designs, differs from the preceding types in having a rigid envelope. Girders are built up into transverse ring forms and these are connected by longitudinals or stringers. This structure is further reinforced by a keel similar to that of the semi-rigids, except that it is internal and is inverted with respect to the semi-rigid keel. The structure is braced with piano wire. Civil engineers will probably notice what a complicated indeterminate structure this forms, and will comprehend the design problem involved, especially when using a factor of safety of 2, before the development of the present physical methods of analyzing indeterminate stresses. The Germans had reduced the design problem to the application of empirical formulae, based upon experience gained from more than one hundred Zeppelins.

The passengers' quarters are built along the bottom, or may be integral with this keel and the power cars are slung directly from the envelope. The Zeppelin has, as stated before, more than one gas bag or cell. These gas cells are right circular cylinders, their axes being about one-third their diameter, and are arranged so that their axes coincide with the longitudinal center line of the envelope. We can get an idea of the shape of these gas cells, and their relativve positions to one another, and to the envelope, by thinking of the felt waddings in a shot gun shell as the gas cells, and the shell itself as the envelope.

Helium will be used in American rigids, because of public opinion, even though it materially reduces the pay load and increases the initial cost of the equipment. The fire hazard has been solved by the use of metal covering and gas bags, thereby eliminating all combustible structural material. The use of heavy oil engines, in place of gasoline motors, has eliminated the highely combustible gasoline.

Because of the nature of the rigid's design it is not limited in size, but as it increases in size the proportion of gross lift devotable to useful load also increases, while doubling the gross lift does not require doubling the horsepower. Hence this ship increases in efficiency as we increase its size. Passengers experience no noise, vibration or swaying motion of any kind. Cruising speeds average from 65 to 75 miles an hour, with maximum speed around 85 miles an hour. The rigid air-

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craft offers the safest, most comfortable, as well as speedy means of travel. As the rigid can carry large loads it offers a fast method for transportation of high class merchandise. A photo of the rigid Shenandoah is shown on these pages. While this is a military ship and differs greatly from a commercial rigid, it shows the position of the longitudinals, which correspond to the edges running along the envelope from stem to stern.

The heavier-than-air craft are classed under three heads, namely, ornithoper, helicopter and orthopter, or airplane (using this term in its broader sense). As the ornithoper and the helicopter have not been developed to a stage applicable to commercial use we will omit further classification of them and pass onto the airplane. The airplane is classified variously according to certain points of construction or application. When classified structurally, that is with regard to the number of wings, they are known as monoplanes or multiplanes. Of the multiplanes, the biplane is by far the most numerous, and at present outnumber the monoplanes. When classified with regard to the medium from which they operate, they are land planes and sea planes. Planes that can operate from either land or water are known as amphibians. Present amphibian types have wheels attached to the boat hull so as to make contact with the ground. Airplanes are also classified as to whether or not they are equipped with power plants. Those not so equipped are known as gliders or soaring planes; those equipped with power plants are divided with respect to this equipment into single engined or multi-engined groups.

As new commercial uses for airplanes appear every day and as there are so many specialized uses for them, probably the most general classification would be with respect to size—in terms of weight. The first group would be the light planes under 1200 pounds, including passengers. The second group would be the medium sized planes ranging from 1200 to 2500 pounds. If used in passenger work this class would be known as the taxi plane carrying a maximum of five passengers. The third group would include all those above 2500 pounds and might be called airliners. The light plane is generally of the biplane construction, in preference to the monoplane, and few have a speed exceeding ninety miles per hour.

The medium sized planes are still within the limits of the single engined class. The general tendency is to mount the motor in the nose of the fuselage or body. The motor and its accessories are designed in one compact unit, which is easily removed, and only half an hour is required to change power plants for overhaul. The monoplane is the ideal type structure areodynamically. It offers less resistance in passing through the air, thus allowing high speed and economical fuel consumption. This size plane provides the fastest means of transportation known and will be used whenever speed is required. For use over water, the fuselage will be replaced by some form of flying boat hull.

Two types of modern construction are shown. The Fokker has a fuselage constructed of welded seamless steel tubing and a plywood wing. This wing warps and disintegrates in tropical climates, making its use subject to climatic conditions. The Stout plane is constructed entirely of duraluminum and is the coming type of airplane. The fuselage in both planes are below the wings, giving the passengers an unobstructed view of the scenery below.

The large plane is generally built with more than one motor with a biplane construction of wood and metal.

Now consider these types from the commercial standpoint. The rigid is essentially a long distance craft capable of carrying large loads at cruising speeds of sixty-five to seventy-five miles an hour. Hence a type of craft suitable for long distance passenger and freight service. What better method of sight-seeing could we have than to stretch out comfortably in a steamer chair aboard a seemingly noiseless and motionless craft and gaze down upon the broad panorama of fields, forests, rolling country-side or ugged mountains. A rigid will make the trip from New York to San Francisco, stopping at Chicago, in fifty hours, whereas the fastest transcontinental trains require four days and four nights. Two days are required for the New York to London trip with all the facilities provided on board ocen liners except the swimming pool and sea sickness. Rigids offer an excellent means of transporting high class freight such as silks or perishable merchandise.

A rigid of twice the capacity of the Los Angeles would have a maximum speed of eighty-five miles per hour and with a full fuel reserve, passengers, freight and express would have no difficulty in making a 6,000 mile non-stop flight. If driven at a cruising speed of seventy-five miles per hour, it could cover 8,000 miles with a pay load of from 50 to 125 passengers, three to six tons of mail and up to twelve tons of freight.

Light planes provide a very quick and economical means of travel, having a better gasoline mileage than a Ford and a speed of 70 to 90 miles per hour. Being one or two seaters, they provide an excellent vehicle for pleasure use and for commuting.

The medium sized plane has a great variety of uses. There will be the high speed plane to provide the fastest means of transportation known. This type will be used for inter-city and trans-continental trips where time is the primary factor. The taxi plane will furnish greater comfort at less speed. It will be for charter or used regularly for small traffic air routes and as feeders for the long distance routes.

The air mail plane must have reasonably high speed and carry a fairly large load of mail. The U. S. Air Mail maintains a thirty hour transcontinental service. This cuts from three to five days from the time required to do business, by mail, between two industrial centers. In banking alone there has been large reduction in the checks and other negotiable papers which are unavailable for use during transit.

The medium size plane also has its use in the field of aerial photography. Real estate dealers find an aeroscope of large estates a real help in adverttising and for exhibition. The making of maps, accurate in every detail, by this method can be done at a few per cent of the cost involved by other methods. Airscapes have revolutionized timber surveying. On large ranches airplanes are used for inspection and transportation. The use of planes to spread insecticide has achieved results otherwise unattainable. This use has been termed "dusting," as the air current from the propeller throws the insecticide down in clouds over the fields or orchards; covering an entire field or orchard in a few minutes.

The larger planes are used for passenger air routes having more traffic than can be handled by the smaller machines. They afford the passenger more room than the smaller plane and can operate more economically when filled to capacity. It must be remembered that the airplane is limited to non-stop flights of 700 to 900 miles; for longer flights the fuel absorbs too large a proportion of the useful load.

The larger airplanes also carry express but cannot compete with lighter-than-air craft either in economy or capacity. All things considered, the rigid offers the best means of transportation for distances of more than 700 miles.